CLAIMS

The invention claimed is:

1. A radiation-patterning tool configured to be utilized to print a pair of structures in a radiation-sensitive material as radiation is passed through the radiation-patterning tool and onto the radiation-sensitive material; the structures being separated from one another on the radiation-sensitive material by a distance of less than or equal to a wavelength of the radiation utilized to print the structures; the tool comprising:

two separate and discrete features, one of the two features corresponding to one of the structures of the pair of structures and the other of the two features corresponding to the other structure of the pair of structures; and

at least one element between the features which is at least partially transparent to the radiation passed through the radiation-patterning tool but does not correspond to a discrete structure printed in the radiation-sensitive material; the element modifying at least one of the structures printed from the pair of features.

2. The radiation-patterning tool of claim 1 wherein the at least one element is a rim contacting both of the two features.

3. The radiation-patterning tool of claim 1 wherein the at least one element is only one element.

4. The radiation-patterning tool of claim 1 wherein the at least one element does not physically contact either of the two features.

5. The radiation-patterning tool of claim 1 wherein the at least one element physically contacts at least one of the two features.

6. The radiation-patterning tool of claim 1 wherein the at least one element has a lower transmission of the radiation than either of the two features.

7. The radiation-patterning tool of claim 1 wherein the element is a rim shifter contacting both of the two features, and wherein the element joins to other rim shifters along edges of the features so that the edges of both features are entirely in contact with rim shifters.

8. The radiation-patterning tool of claim 1 wherein the two features are part of a linear expanse of a plurality of features; wherein the element is part of a linear expanse of elements arranged between the features of the linear expanse of features; wherein the elements are rim shifters contacting the features adjacent the elements; and wherein the elements join to other rim shifters along edges of the features so that the edges of all of the features of the linear expanse are entirely in contact with rim shifters.

9. The radiation-patterning tool of claim 1 further comprising one or more outriggers surrounding the features and the element.

10. The radiation-patterning tool of claim 9 wherein the one or more outriggers includes at least two outriggers, with a first of the at least two outriggers entirely and continuously surrounding the features and the element, and a second of the at least two outriggers entirely and continuously surrounding said one of the at least two outriggers.

11. The radiation-patterning tool of claim 9 wherein the one or more outriggers includes at least two outriggers, with a first of the at least two outriggers discontinuously surrounding the features and the element, and a second of the at least two outriggers discontinuously surrounding said one of the at least two outriggers.

12. The radiation-patterning tool of claim 1 wherein the two features shift a phase of the radiation passing therethrough equivalently to one another; and wherein the at least one element shifts the phase of the radiation passing therethrough by from about 170° to about 190° relative to the radiation passing through the two features.

13. The radiation-patterning tool of claim 12 further comprising one or more outriggers surrounding the features and the element; and wherein the outriggers do not shift the phase of the radiation relative to the phase of the radiation passing through the two features.

14. The radiation-patterning tool of claim 13 wherein the one or more outriggers includes at least two outriggers, with a first of the at least two outriggers entirely and continuously surrounding the features and the element, and a second of the at least two outriggers entirely and continuously surrounding said one of the at least two outriggers.

15. The radiation-patterning tool of claim 13 wherein the one or more outriggers includes at least two outriggers, with a first of the at least two outriggers discontinuously surrounding the features and the element, and a second of the at least two outriggers discontinuously surrounding said one of the at least two outriggers.

16. The radiation-patterning tool of claim 1 wherein the two features shift a phase of the radiation passing therethrough equivalently to one another, and wherein the at least one element shifts the phase of the radiation passing therethrough by about 180° relative to the radiation passing through the two features.

17. The radiation-patterning tool of claim 16 wherein the at least one element has a lower transmission of the radiation than at least one of the two features.

18. The radiation-patterning tool of claim 16 wherein the at least one element has a lower transmission of the radiation than either of the two features.

19. A radiation-patterning tool configured to be utilized to print a plurality of structures in a radiation-sensitive material as radiation is passed through the radiation-patterning tool and onto the radiation-sensitive material; some of the structures being adjacent one another and being separated from one another on the radiation-sensitive material by distances comparable to minimum widths of the structures; the tool comprising:

a plurality of separate and discrete features, each of the features corresponding to one of the printed structures; and

elements between at least some of the features; the elements being at least partially transparent to the radiation passing through the radiation-patterning tool but not corresponding to a discrete structure printed in the radiation-sensitive material; the elements modifying the structures printed from the at least some of the features.

20. The radiation-patterning tool of claim 19 wherein the elements are rims and at least one of the elements contacts at least two of the features.

21. The radiation-patterning tool of claim 19 wherein the features include a pair of the features spaced from one another by only one of the elements.

22. The radiation-patterning tool of claim 19 wherein at least one of the elements does not physically contact any of the two features.

23. The radiation-patterning tool of claim 19 wherein the at least one of the elements physically contacts one or more of the features.

24. The radiation-patterning tool of claim 19 wherein the elements have a lower transmission of the radiation than the features.

25. The radiation-patterning tool of claim 19 wherein the elements shift a phase of the radiation passing therethrough by from about 170° to about 190° relative to the radiation passing through the features.

26. The radiation-patterning tool of claim 19 wherein the elements shift a phase of the radiation passing therethrough by about 180° relative to the radiation passing through the features.

27. The radiation-patterning tool of claim 26 wherein the elements have a lower transmission of the radiation than the features.

28. A method of printing structures in a radiation-sensitive material, comprising:

providing a radiation-patterning tool and providing the radiation-sensitive material; defining a radiation-patterning tool domain to consist of features present on the radiation-patterning tool and defining a printed domain to consist of structures printed in the radiation-sensitive material using the radiation-patterning tool;

passing actinic radiation through the radiation-patterning tool and onto the radiation-sensitive material to print the structures into the radiation-sensitive material; and

wherein:

the actinic radiation has a wavelength;

the printed domain comprises two structures separated from one another by an edge-to-edge gap that is less than or about equal to the wavelength;

the radiation-pattering tool domain comprises a pair of features through which the radiation is passed to print the pair of structures; and

the radiation-patterning tool domain further comprises an element between the pair of features and which modifies radiation that passes through the pair of features.

29. The method of claim 28 wherein the actinic radiation comprises a distribution of wavelengths, and wherein the edge-to-edge gap is less than a predominant wavelength of said distribution.

30. The method of claim 28 wherein the actinic radiation comprises a distribution of wavelengths, and wherein the edge-to-edge gap is less than a central wavelength of said distribution.

31. The method of claim 28 wherein the element has a lower transmission of the radiation than each of the features of the pair of features.

32. The method of claim 28 wherein the element physically contacts at least one of the features of the pair of features.

33. The method of claim 28 wherein the element physically contacts both of the features of the pair of features.

34. The method of claim 28 wherein the element does not physically contact either of the features of the pair of features.

35. The method of claim 28 wherein each of the features of the pair of features are approximately equal in size and shape to one another; wherein the features each have a width and a length extending orthogonally to the width; wherein an axis is defined extending through the element and along the widths of the features; wherein the element has a width defined to extend along the axis and a length extending orthogonally to the width; and wherein the length of the element is less than the lengths of the features.

36. The method of claim 35 wherein the features are approximately square in shape.

37. The method of claim 35 wherein the features are approximately rectangular in shape.

38. The method of claim 28 wherein each of the features of the pair of features are approximately equal in size and shape to one another; wherein the features each have a width and a length extending orthogonally to the width; wherein an axis is defined extending through the element and along the widths of the features; wherein the element has a width defined to extend along the axis and a length extending orthogonally to the width; and wherein the length of the element is greater than the lengths of the features.

39. The method of claim 38 wherein the features are approximately square in shape.

40. The method of claim 38 wherein the features are approximately rectangular in shape.

41. The method of claim 28 wherein the element shifts a phase of the radiation passing therethrough by from about 170° to about 190° relative to the radiation passing through the features.

42. The method of claim 41 wherein the element has a lower transmission of the radiation than either of the features of the pair of features.

43. The method of claim 41 wherein the element has a transmission of the radiation that is less than about 20% of the transmission through either of the features of the pair of features.

44. The method of claim 28 wherein the element shifts a phase of the radiation passing therethrough by about 180° relative to the radiation passing through the features.

45. The method of claim 44 wherein the element has a lower transmission of the radiation than either of the features of the pair of features.

46. The method of claim 44 wherein the element has a transmission of the radiation that is less than about 20% of the transmission through either of the features of the pair of features.

47. The method of claim 44 wherein the wavelength is less than 250 nanometers.

48. A method of printing structures in a radiation-sensitive material, comprising:

providing a radiation-patterning tool and providing the radiation-sensitive material; defining a radiation-patterning tool domain to consist of features present on the radiation-patterning tool and defining a printed domain to consist of structures printed in the radiation-sensitive material using the radiation-patterning tool;

passing actinic radiation through the radiation-patterning tool and onto the radiation-sensitive material to print the structures into the radiation-sensitive material; and

wherein:

the actinic radiation has a wavelength;

the printed domain comprises a plurality of structures with adjacent structures of the plurality being separated from one another by an edge-to-edge gap that is less than or about equal to the wavelength;

the radiation-pattering tool domain comprises a plurality of features through which the radiation is passed to print the plurality of structures;

the radiation-patterning tool domain further comprises a plurality of elements arranged such that at least one element is between adjacent features of the plurality of features; and

radiation passing through the elements modifies radiation passing through the features.

49. The method of claim 48 wherein the wavelength is less than 250 nanometers.

50. The method of claim 48 wherein the elements have a lower transmission of the radiation than the features.

51. The method of claim 48 wherein at least one of the elements physically contacts at least one of the features.

52. The method of claim 48 wherein at least one of the elements physically contacts at least two of the features.

53. The method of claim 48 wherein the at least one of the elements does not physically contact any of the features.

54. The method of claim 48 wherein each of the features are approximately equal in size and shape to one another; wherein the individual features have a width and a length extending orthogonally to the width; wherein an axis is defined extending through at least some of the elements and along the widths of the features; wherein the at least some of the elements have widths defined to extend along the axis and lengths extending orthogonally to the widths; and wherein the lengths of the at least some of the elements are less than the lengths of the features.

55. The method of claim 54 wherein the features are approximately square in shape.

56. The method of claim 54 wherein the features are approximately rectangular in shape.

57. The method of claim 48 wherein each of the features are approximately equal in size and shape to one another; wherein the individual features have a width and a length extending orthogonally to the width; wherein an axis is defined extending through at least some of the elements and along the widths of the features; wherein the at least some of the elements have widths defined to extend along the axis and lengths extending orthogonally to the widths; and wherein the lengths of the at least some of the elements are greater than the lengths of the features.

58. The method of claim 57 wherein the features are approximately square in shape.

59. The method of claim 57 wherein the features are approximately rectangular in shape.

60. The method of claim 48 wherein the elements shift a phase of the radiation passing therethrough by from about 170° to about 190° relative to the radiation passing through the features.

61. The method of claim 60 wherein the individual elements have a lower transmission of the radiation than the individual features.

62. The method of claim 60 wherein the individual elements have a transmission of the radiation that is less than about 20% of the transmission through the individual features.

63. The method of claim 48 wherein the elements shift a phase of the radiation passing therethrough by about 180° relative to the radiation passing through the features.

64. The method of claim 63 wherein the individual elements have a lower transmission of the radiation than the individual features.

65. The method of claim 63 wherein the individual elements have a transmission of the radiation that is less than about 20% of the transmission through the individual features.

66. A method of forming aligned structures with a radiation-sensitive material, comprising, in the following sequential order:

providing a substrate having a radiation-sensitive material thereover; the substrate and radiation-sensitive material having at least three defined regions; the at least three defined regions including a first region, a second region and a third region;

exposing the first region of the radiation-sensitive material to a first dose of actinic radiation; exposing second region of the radiation-sensitive material to a second dose of actinic radiation less than the first dose; and leaving the third region of the radiation-sensitive material not exposed to either the first or second dose of the actinic radiation;

developing the radiation-sensitive material; the developing removing the radiation-sensitive material from over the first region of the substrate, and leaving the radiation sensitive material over the second and third regions of the substrate;

treating the first region of the substrate;

exposing the second and third regions of the radiation-sensitive material to a blanket dose of the actinic radiation;

developing the radiation-sensitive material; the developing removing the radiation-sensitive material from over the second region of the substrate, and leaving the radiation sensitive material over the third region of the substrate; and

while the radiation-sensitive material remains over the third region of the substrate, treating the second region of the substrate.

67. The method of claim 66 wherein the substrate corresponds to a radiation-patterning tool substrate and comprises a layer of opaque material over a transparent base; the treating of the first and second regions comprising removing the opaque material from over the base.

68. The method of claim 67 wherein the treating of the first region further comprises etching into the base.

69. The method of claim 67 wherein the treated first region corresponds to a rim shifter or outrigger; wherein the treated second region corresponds to a feature; and wherein the rim shifter or outrigger modifies a pattern produced by the feature during a printing operation utilizing the radiation patterning tool substrate.

70. The method of claim 67 wherein the treated second region corresponds to a rim shifter or outrigger; wherein the treated first region corresponds to a feature; and wherein the rim shifter or outrigger modifies a pattern produced by the feature during a printing operation utilizing the radiation patterning tool substrate.

71. The method of claim 66 further comprising removing the radiation-sensitive material from over the third region, and subsequently utilizing the substrate as a radiation-patterning tool during a printing operation.